

MEMORANDUM

SUBJECT: DOCUMENTATION OF APPLICATOR EXPOSURE ASSESSMENT FOR
CHLORPYRIFOS REREGISTRATION ELIGIBILITY DOCUMENT -
APPLICATION IN THE RESIDENTIAL ENVIRONMENT

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TO: Chlorpyrifos File (059101)

OREB has conducted exposure assessments for a number of application scenarios for homeowner application and for professional applicators using chlorpyrifos in the residential environment for the chlorpyrifos RED. This memorandum documents the sources, methods, and assumptions used for these estimates.

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1.0 AEROSOL SPRAY CAN APPLICATION

OREB used PHED V1.1 to determine the unit exposures of individuals spraying aerosol products containing chlorpyrifos. Three scenarios were evaluated; when the applicators wears a long sleeved shirt, long pants, and shoes; wearing long pants, short sleeves, and shoes; and assuming no clothing (shorts only). Gloves were not assumed to be worn because homeowners using these products would not be expected to wear gloves, although professional applicators might. Data in PHED did not address the wearing of gloves. Therefore, even for commercial applicators, gloves were not considered. Hands contributed 22 percent of the dermal exposure. Commercial applicators often, in fact, wear gloves so the estimates for commercial applicators should be considered to be conservative.

Subsetting of the applicator file (APPL.FILE) for aerosol spray can yielded 15 replicates coming from a single study with hand, dermal uncovered, and inhalation grades equal to A (AEROSOL1.APPL). A separate set of summary statistics, using the same replicates, was generated for respiratory exposure analysis (AEROSOL3.APPL). Additional assumptions were necessary to estimate exposures of individuals using aerosol spray can products:

- 1) An average applicator weighs 70 kg and has a respiratory volume of 25 liters per minute, used as the default value in PHED.
- 2) A typical aerosol product is 16 ounces and contains 1 percent active ingredient (w/w, 0.16 oz or 4.5 g).
- 3) During a single application, the entire contents of the aerosol spray can are dispensed. OREB realizes that this is very conservative for the homeowner situation but must make this assumption in lieu of more detailed information on the use of these products.
- 4) One can of product is sprayed on a given day by a resident. A commercial applicator is assumed to apply 10 cans per day.
- 5) One percent of the chlorpyrifos depositing on the skin is absorbed (Ref 1-1). Material inhaled is assumed to be completely absorbed.

The estimated daily exposures of individuals using aerosol products are presented in Table 1-1. The summary statistics produced by PHED are presented in Tables 1-2 (Shorts and shoes), 1-3 (long sleeves, long pants), 1-4 (Short sleeves, long pants), and 1-5 (Inhalation).

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Table 1-1. Estimates of Dermal and Respiratory Exposure of Individuals Applying a 16 Ounce Aerosol Spray Can Containing 1 Percent (w/w) Chlorpyrifos.

Clothing Scenario	Unit Exposure (mg/lb ai)		Exposure (µg/kg/day)		
	Dermal	Resp.	Dermal ¹	Resp. ²	Total
Shorts and Shoes	479	1.1	0.68	0.16	0.84
Long Pants, long Sleeve Shirt, Shoes	187	1.1	0.26	0.16	0.42
Long Pants, Short Sleeve Shirt, Shoes	233	1.1	0.33	0.16	0.49

Assumptions: Body Weight = 70 kg, Dermal Absorption = 1%,
Respiratory Absorption = 100%, 1 16-ounce can
sprayed per day

$$^1 \text{ Dermal Exp. (}\mu\text{g/kg/day)} = \frac{\text{Unit exp (mg/lb ai)} \times 0.01 \text{ lbs} \times 0.01}{70 \text{ kg}}$$

$$^2 \text{ Respiratory Exp. (}\mu\text{g/kg/day)} = \frac{\text{Unit exp (mg/lb ai)} \times 0.01 \text{ lbs}}{70 \text{ kg}}$$

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Table 1-2. Summary Statistics and Subset Specifications for Total Potential Dermal Exposure Derived from Phed V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Aerosol Products Containing Chlorpyrifos and Wearing Minimal Clothing (Shorts and Shoes Only).

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: No clothing (total deposition)						
PATCH	DISTRIB.	MICROGRAMS		PER LB AI	SPRAYED	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	41990	69769.2667	124.9606	41026.2018	15
NECK.FRONT	Lognormal	2100	7149.9	217.7599	2512.8897	15
NECK.BACK	Lognormal	2134	2612.3533	80.9252	1995.1883	15
UPPER ARMS	Lognormal	106404.15	132042.22	69.3376	99936.3098	15
CHEST	Lognormal	49700	169214.3	217.7599	59471.7219	15
BACK	Lognormal	68870	84307.7667	80.9252	64390.1671	15
FOREARMS	Lognormal	75262	80022.14	82.2066	48812.2038	15
THIGHS	Lognormal	22347	48362.4733	124.2553	29982.996	15
LOWER LEGS	Lognormal	16933.7	62734.42	177.4078	24840.1299	15
FEET						0
HANDS	Lognormal	110000	121026.6667	51.0748	105679.5485	15
TOTAL DERM:	478647.3568	495740.85	777241.5067		478647.3568	

95% C.I. on Mean: Dermal: [-6027650.415, 7582133.4288]

Data File: APPLICATOR
Number of Records: 15
Subset Name: AEROSOL1.APPL

Subset Specifications for AEROSOL1.APPL

with Dermal Grade Uncovered Equal to "A"
subset originated from AEROSOL.APPL
with Application Method Equal to 4
subset originated from APPL.FILE

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Table 1-3. Summary Statistics and Subset Specifications for Total Potential Dermal Exposure Derived from Phed V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Aerosol Products Containing Chlorpyrifos and Wearing Long Pants, Long Sleeve Shirt, and Shoes.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS		PER LB AI SPRAYED		
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	41990	69769.2667	124.9606	41026.2018	15
NECK.FRONT	Lognormal	2100	7149.9	217.7599	2512.8897	15
NECK.BACK	Lognormal	2134	2612.3533	80.9252	1995.1883	15
UPPER ARMS	Other	5907.3	5907.3	0	5907.0886	15
CHEST	Other	7206.5	7206.5	0	7206.2421	15
BACK	Other	7206.5	7206.5	0	7206.2421	15
FOREARMS	Other	2456.3	2737.4233	39.7741	2625.4536	15
THIGHS	Other	7754.6	7754.6	0	7754.3224	15
LOWER LEGS	Other	4831.4	4831.4	0	4831.2271	15
FEET						0
HANDS	Lognormal	110000	121026.6667	51.0748	105679.5485	15
TOTAL DERM:	186576.4283	191586.6	236201.91		186744.4042	

95% C.I. on Mean: Dermal: [-1492611.595, 1965015.4152]

Data File: APPLICATOR
Number of Records: 15
Subset Name: AEROSOL1.APPL

Subset Specifications for AEROSOL1.APPL

With Dermal Grade Uncovered Equal to "A"
Subset originated from AEROSOL.APPL
With Application Method Equal to 4
Subset originated from APPL.FILE

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Table 1-4. Summary Statistics and Subset Specifications for Total Potential Dermal Exposure Derived from Phed V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Aerosol Products Containing Chlorpyrifos and Wearing Long Pants, Long Sleeve Shirt, and Shoes.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, short sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS		PER LB AI SPRAYED		
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	41990	69769.2667	124.9606	41026.2018	15
NECK.FRONT	Lognormal	2100	7149.9	217.7599	2512.8897	15
NECK.BACK	Lognormal	2134	2612.3533	80.9252	1995.1883	15
UPPER ARMS	Other	5907.3	5907.3	0	5907.0886	15
CHEST	Other	7206.5	7206.5	0	7206.2421	15
BACK	Other	7206.5	7206.5	0	7206.2421	15
FOREARMS	Lognormal	75262	80022.14	82.2066	48812.2038	15
THIGHS	Other	7754.6	7754.6	0	7754.3224	15
LOWER LEGS	Other	4831.4	4831.4	0	4831.2271	15
FEET						0
HANDS	Lognormal	110000	121026.6667	51.0748	105679.5485	15
TOTAL DERM:	232932.3321	264392.3	313486.6267		232931.1544	

95% C.I. on Mean: Dermal: [-1710565.021, 2337538.2751]

Data File: APPLICATOR
 Number of Records: 15
 Subset Name: AEROSOL1.APPL

Subset Specifications for AEROSOL1.APPL

With Dermal Grade Uncovered Equal to "A"
 Subset originated from AEROSOL.APPL
 With Application Method Equal to 4
 Subset originated from APPL.FILE

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Table 1-5. Summary Statistics and Subset Specifications for Inhalation Exposure derived from PHED V 1.1 to Estimate the potential Dermal and Respiratory Exposures of Individuals Applying Aerosol Products Containing Chlorpyrifos.

SUMMARY STATISTICS FOR INHALATION EXPOSURES

	DISTRIB. TYPE	Median	Mean	Coef of Var	NANOGRAMS PER LB AI SPRAYED Geo. Mean	Obs.
EXPOSURE	Other	1096491.228	1557948.612	61.6887	1374297.615	15

95% C.I. on Geo. Mean: [547065.145, 3452411.3845]

Number of Records: 15

Data File: APPLICATOR

Subset Name: AEROSOL3.APPL

Subset Specifications for AEROSOL3.APPL

With Airborne Grade Equal to "A"

Subset originated from AEROSOL.APPL

With Application Method Equal to 4

Subset originated from APPL.FILE

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**2.0 BROADCAST - GRANULAR - BELLY GRINDER, PUSH TYPE APPLICATOR,
HAND APPLICATION**

The exposure assessments for granular application in the residential environment were conducted using PHED V1.1. Subsetting of the Mixer/loader/applicator file (MLAP.FILE) yielded 60 replicates for Method of Application Solid Broadcast Spreader (belly grinder) OR Solid Broadcast Spreader (Scotts type residential) in subset GRANULAR.BROADCAST.RES.MLAP. Five of these replicates contained E grade data for airborne and hand measurements. The crop for these replicates was ornamentals. A second subset was created removing these five replicates yielding a dataset containing with 55 replicates graded C or better data for airborne, Dermal Grade Uncovered, and Hand Grade (GRANULAR.BROADCAST.RES.ABC.MLAP. The subset specifications are presented below:

<< Specifications >>
Subset Specifications for
GRANULAR.BROADCAST.RES.ABC.MLAP

With Airborne Grade Equal to "A" "B" "C" and
With Dermal Grade Uncovered Equal to "A" "B" "C" and
With Hand Grade Equal to "A" "B" "C"
Subset originated from GRANULAR.BROADCAST.RES.MLAP
With Application Method Equal to 18 or Equal to 19
Subset originated from MLAP.FILE

It was assumed that an average application dispensed 0.97 lbs of active ingredient. This was the average amount of active ingredient handled in the 55 replicates used to calculate exposures. A summary of the exposures is presented in Table 2-1. The amounts handled are presented in Table 2-2. The unit exposure values for applicators under various clothing scenarios from with long pants, long sleeves, gloves to no clothing (total deposition) are presented in Tables 2-3 to 2-7.

PHED analysis of application of granular products by hand while wearing gloves yielded a single study. Almost all of the values in this subset were non-detected samples. Therefore, any exposure number would be almost entirely based on the level of detection for a different chemical. OREB considers exposure from this scenario to be negligible. The summary statistics from this subset, which included only study 0520, are presented in Table 2-8.

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Table 2-1. Estimates of Dermal and Respiratory Exposure of Individuals Applying a Granular Formulation of Chlorpyrifos Using Belly Grinders or Push-Type Spreaders.

Clothing Scenario	Unit Exposure (mg/lb ai)		Exposure (µg/kg/day)		Total
	Dermal	Respiratory	Dermal	Respiratory	
Shorts and Shoes	303	0.029	2.94	0.028	2.97
Long Pants, Long Sleeves, Gloves	17	0.029	0.16	0.028	0.19
Long Pants, Long Sleeves, No Gloves	6.9	0.029	0.07	0.028	0.10
Long Pants, Short Sleeves, Gloves	95	0.029	0.92	0.028	0.95
Long Pants, Short Sleeves, No Gloves	85	0.029	0.82	0.028	0.85

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Table 2-2. Amounts of Active Ingredient Handled During Studies of Granular Broadcast Application Using Belly Grinders or Push-Type Spreaders. Data are from PHED V1.1 file BROADCAST.RES.ABC.MLAP.

Record I.D.	Applied (lb)
0459*A*1	.0288
0459*A*2	.0425
0504*DV*01	.8200
0504*JJ*01	1.2600
0504*MS*01	1.2800
1027*B*01	1.1100
1027*B*02	1.1100
1027*B*03	1.1100
1027*B*04	1.1100
1027*D*03	1.6700
1027*D*01	1.8400
1027*D*02	1.4900
1027*D*04	1.6700
1027*D*05	1.6700
1027*F*01	1.6500
1027*F*02	1.6500
1027*F*03	1.6700
1027*F*04	1.6700
0459*A*3	.0106
0459*A*4	.0100
0459*B*1	.0125
0459*B*2	.0088
0459*B*3	.0125
0459*B*4	.0169
0459*B*5	.0119
0459*B*6	.0150
0459*C*1	.0075
0459*C*2	.0088
0459*C*3	.0081
0504*JC*01	1.0000
0504*JM*01	1.2400
0504*MD*01	1.3600
0504*NB*01	1.3700
1027*A*02	1.1100
1027*A*03	1.1100
1027*A*01	1.1100
1027*C*01	1.1100
1027*C*02	1.1100
1027*E*01	1.6700
1027*E*02	1.6700
0459*C*4	.0069

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Table 2-2. Amounts of Active Ingredient Handled During Studies of Granular Broadcast Application Using Belly Grinders or Push-Type Spreaders. Data are from PHED V1.1 file BROADCAST.RES.ABC.MLAP.

0459*C*5	.0138
0459*C*6	.0081
0504*DS*01	1.3300
0504*IC*01	1.2900
1027*A*04	1.1100
1027*A*05	1.1100
1027*A*06	1.1100
1027*C*03	1.3900
1027*C*04	1.3900
1027*C*05	1.0500
1027*E*03	1.6700
1027*E*04	1.6700
1027*E*05	1.6700
1027*E*06	1.6700
MEAN Amt	0.97

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Table 2-3. Summary Statistics from PHED V1.1 for Applicators Using Push-type Spreaders or Belly Grinders for Granular Application in the Residential Environment - No Clothing (total deposition).

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: No clothing (total deposition)						
PATCH LOCATION	DISTRIB. TYPE	Median	Mean	PER AVERAGE Coef of Var	LB AI Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1776.71	2174.7336	171.7196	601.4068	25
NECK.FRONT	Lognormal	379.635	700.551	121.2141	228.0907	25
NECK.BACK	Lognormal	212.74	437.2069	137.6599	146.6623	25
UPPER ARMS	Lognormal	22420.968	25872.2826	77.5722	19160.7819	16
CHEST	Lognormal	17694.4425	25484.3406	79.5568	18980.6987	16
BACK	Lognormal	13371.6075	21602.9703	96.7841	14203.9856	16
FOREARMS	Lognormal	95536.9415	117315.7996	85.0896	78315.4859	16
THIGHS	Lognormal	216563.058	245975.148	84.0722	149046.2518	16
LOWER LEGS	Lognormal	12953.983	54940.2324	165.2406	19624.4353	16
FEET						0
HANDS	Lognormal	3879.4154	4794.0172	114.5294	2205.1888	38
TOTAL DERM:	302512.9878	384789.5009	499297.2822		302512.9878	
INHALATION:	Lognormal	22.2523	90.2732	126.7821	28.5427	55
COMBINED:	302541.5305	384811.7532	499387.5554		302541.5305	
95% C.I. on Mean: Dermal: [-3366568.784, 4365163.3488]						
95% C.I. on Geo. Mean: Inhalation: [.9447, 862.3362]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 55			
Data File: MIXER/LOADER/APPLICATOR			Subset Name: BROADCAST.RES.ABC.MLAP			

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Table 2-4. Summary Statistics from PHED V1.1 for Applicators Using Push-type Spreaders or Belly Grinders for Granular Application in the Residential Environment - Long pants, long sleeves, gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1776.71	2174.7336	171.7196	601.4068	25
NECK.FRONT	Lognormal	379.635	700.551	121.2141	228.0907	25
NECK.BACK	Lognormal	212.74	437.2069	137.6599	146.6623	25
UPPER ARMS	Lognormal	941.094	3093.9014	161.4237	651.2703	55
CHEST	Lognormal	1410.5925	4627.3461	182.6958	852.898	54
BACK	Lognormal	1148.07	3775.7671	161.3397	816.5264	55
FOREARMS	Lognormal	391.314	2282.599	337.8637	318.3762	55
THIGHS	Lognormal	438.918	3080.5869	164.1543	655.0604	55
LOWER LEGS	Lognormal	273.462	1519.8377	146.9528	310.19	55
FEET						0
HANDS	Normal	7175.04	12280.1385	98.7737	6823.4012	15
TOTAL DERM:	16860.6196	14147.5755	33972.6682		11403.8823	
INHALATION:	Lognormal	22.2523	90.2732	126.7821	28.5427	55
COMBINED:	16889.1623	14169.8278	34062.9414		11432.425	
95% C.I. on Mean: Dermal: [-202029.1517, 269974.4881]						
95% C.I. on Geo. Mean: Inhalation: [.9447, 862.3362]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 55			
Data File: MIXER/LOADER/APPLICATOR			Subset Name: BROADCAST.RES.ABC.MLAP			

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Table 2-5. Summary Statistics from PHED V1.1 for Applicators Using Push-type Spreaders or Belly Grinders for Granular Application in the Residential Environment - Long pants, long sleeves, no gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1776.71	2174.7336	171.7196	601.4068	25
NECK.FRONT	Lognormal	379.635	700.551	121.2141	228.0907	25
NECK.BACK	Lognormal	212.74	437.2069	137.6599	146.6623	25
UPPER ARMS	Lognormal	941.094	3093.9014	161.4237	651.2703	55
CHEST	Lognormal	1410.5925	4627.3461	182.6958	852.898	54
BACK	Lognormal	1148.07	3775.7671	161.3397	816.5264	55
FOREARMS	Lognormal	391.314	2282.599	337.8637	318.3762	55
THIGHS	Lognormal	438.918	3080.5869	164.1543	655.0604	55
LOWER LEGS	Lognormal	273.462	1519.8377	146.9528	310.19	55
FEET						0
HANDS	Lognormal	3879.4154	4794.0172	114.5294	2205.1888	38
TOTAL DERM:	6785.6699	10851.9509	26486.5469		6785.6699	
INHALATION:	Lognormal	22.2523	90.2732	126.7821	28.5427	55
COMBINED:	6814.2126	10874.2032	26576.8201		6814.2126	
95% C.I. on Mean: Dermal: [-118649.8024, 171622.8962]						
95% C.I. on Geo. Mean: Inhalation: [.9447, 862.3362]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 55			
Data File: MIXER/LOADER/APPLICATOR			Subset Name: BROADCAST.RES.ABC.MLAP			

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Table 2-6. Summary Statistics from PHED V1.1 for Applicators Using Push-type Spreaders or Belly Grinders for Granular Application in the Residential Environment - Long pants, short sleeves, gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, short sleeves, gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1776.71	2174.7336	171.7196	601.4068	25
NECK.FRONT	Lognormal	379.635	700.551	121.2141	228.0907	25
NECK.BACK	Lognormal	212.74	437.2069	137.6599	146.6623	25
UPPER ARMS	Lognormal	941.094	3093.9014	161.4237	651.2703	55
CHEST	Lognormal	1410.5925	4627.3461	182.6958	852.898	54
BACK	Lognormal	1148.07	3775.7671	161.3397	816.5264	55
FOREARMS	Lognormal	95536.9415	117315.7996	85.0896	78315.4859	16
THIGHS	Lognormal	438.918	3080.5869	164.1543	655.0604	55
LOWER LEGS	Lognormal	273.462	1519.8377	146.9528	310.19	55
FEET						0
HANDS	Normal	7175.04	12280.1385	98.7737	6823.4012	15
TOTAL DERM:	94857.7293	109293.203	149005.8688		89400.992	
INHALATION:	Lognormal	22.2523	90.2732	126.7821	28.5427	55
COMBINED:	94886.272	109315.4553	149096.142		89429.5347	
95% C.I. on Mean: Dermal: [-1414348.580, 1712360.3182]						
95% C.I. on Geo. Mean: Inhalation: [.9447, 862.3362]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 55			
Data File: MIXER/LOADER/APPLICATOR			Subset Name: BROADCAST.RES.ABC.MLAP			

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Table 2-7. Summary Statistics from PHED V1.1 for Applicators Using Push-type Spreaders or Belly Grinders for Granular Application in the Residential Environment - Long pants, short sleeves, no gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, short sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1776.71	2174.7336	171.7196	601.4068	25
NECK.FRONT	Lognormal	379.635	700.551	121.2141	228.0907	25
NECK.BACK	Lognormal	212.74	437.2069	137.6599	146.6623	25
UPPER ARMS	Lognormal	941.094	3093.9014	161.4237	651.2703	55
CHEST	Lognormal	1410.5925	4627.3461	182.6958	852.898	54
BACK	Lognormal	1148.07	3775.7671	161.3397	816.5264	55
FOREARMS	Lognormal	95536.9415	117315.7996	85.0896	78315.4859	16
THIGHS	Lognormal	438.918	3080.5869	164.1543	655.0604	55
LOWER LEGS	Lognormal	273.462	1519.8377	146.9528	310.19	55
FEET						0
HANDS	Lognormal	3879.4154	4794.0172	114.5294	2205.1888	38
TOTAL DERM:	84782.7796	105997.5784	141519.7475		84782.7796	
INHALATION:	Lognormal	22.2523	90.2732	126.7821	28.5427	55
COMBINED:	84811.3223	106019.8307	141610.0207		84811.3223	
95% C.I. on Mean: Dermal: [-1410718.905, 1693758.4003]						
95% C.I. on Geo. Mean: Inhalation: [.9447, 862.3362]						
Inhalation Rate : 25 Liters/Minute				Number of Records: 55		
Data File: MIXER/LOADER/APPLICATOR				Subset Name: BROADCAST.RES.ABC.MLAP		

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Table 2-8. Summary Statistics from PHED V1.1 for Application of Granular Products by Hand - Long pants, long sleeves, gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, no gloves

PATCH	DISTRIB.	MICROGRAMS		PER LB AI	SPRAYED	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	5796.245	5911.8638	65.7229	4628.6454	16
NECK.FRONT	Lognormal	699.225	788.2688	56.8973	652.267	16
NECK.BACK	Lognormal	490.4515	500.2346	65.7229	391.6546	16
UPPER ARMS	Lognormal	12974.6715	13233.4796	65.7229	10361.0448	16
CHEST	Lognormal	15828.2075	16143.9356	65.7229	12639.7626	16
BACK	Lognormal	15828.2075	16143.9356	65.7229	12639.7626	16
FOREARMS	Lognormal	5394.9665	5502.5809	65.7229	4308.2008	16
THIGHS	Lognormal	17032.043	17371.7842	65.7229	13601.0966	16
LOWER LEGS	Lognormal	10611.587	10823.2582	65.7229	8473.9817	16
FEET						0
HANDS						0
TOTAL DERM:		67696.4161	84655.6045		67696.4161	
INHALATION:	Lognormal	515.8778	523.3865	68.6837	403.2931	16
COMBINED:		68099.7092	85171.4823		68099.7092	
95% C.I. on Mean: Dermal: [-263592.6399, 436431.3225]						
95% C.I. on Geo. Mean: Inhalation: [84.2361, 1930.8268]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 16			
Data File: APPLICATOR			Subset Name: 520.APPL			

3.0 Commercial Indoor Application - Applicator - Crack and Crevice/Broadcast

OREB used PHED V1.1 to determine the unit exposures of professional applicators spraying indoor products (crack and crevice or broadcast) containing chlorpyrifos. The applicators were assumed to wear a long sleeved shirt, long pants, gloves, and shoes. Separate exposure estimates were calculated for workers with no respiratory protection and with a respirator offering 90 percent protection. These estimates are presented in Table 3-1.

Subsetting of the mixer/loader/applicator file (MLAP.FILE) for crack and crevice application (Study 458 selected using browse function for low pressure spray indoors) yielded 16 replicates in file CRACL.N.CREV.MLAP. The summary statistics produced by PHED are presented in Tables 3-2 and 3-3 for dermal and inhalation exposure, respectively.

The unit exposures estimated by PHED were 8164 µg (8.1 mg) and 916472 ng (0.92 mg) per pound active ingredient handled. Additional assumptions were necessary to estimate exposures of individuals using these products:

- 1) An average commercial pesticide applicator weighs 70 kg and has a respiratory volume of 25 liters per minute, used as the default value in PHED.
- 2) A typical application rate is 1 gallon of a 0.5 percent solution per 1600 ft². An average treatment consists of spraying 0.13 pounds of active ingredient. This was derived from a Browse Print of the amounts handled in the same study uses for calculation of exposure. Each replicate consisted of a typical treatment. These data are presented Table 3-4.
- 3) A commercial applicator treats 10 homes per day with chlorpyrifos, 5 days per week, 220 days per year.
- 4) The dermal absorption of chlorpyrifos is assumed to be 1 percent (1). Respiratory absorption is assumed to be 100 percent.

The amount of active ingredient handled per day is:

$$\begin{aligned}\text{Amount Handled (lb/day)} &= 0.13 \text{ lb ai/trt} \times 10 \text{ treatments/day} \\ &= 1.3 \text{ lb ai/day}\end{aligned}$$

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Table 3-1. Summary of Exposures Applying Chlorpyrifos Indoors Using Compressed Air Sprayers. Long sleeve shirts, long pants, and gloves are assumed to be worn.

Scenario	Exposure (mg/lb ai)		Lb ai Handled/day	Exposure (mg/kg/day)		Margin of Exposure (MOE); NOEL = 0.030 mg/kg/day	
				Male (70 kg)	Female (60 kg)	Male	Female
Without Respirator	8.1	0.92	1.3	0.0186	0.0217	1.6	1.4
With Respirator (90% protection)	8.1	0.092	1.3	0.0032	0.0037	9.4	8.1

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The daily Dermal exposure of an adult male is estimated to be:

Dermal Exposure = 1.3 lb ai/day x 8.6 mg/lb ai x 0.01 x 1/70 kg
(mg/kg/day)

$$= 0.0016 \text{ mg/kg/day} = 1.6 \text{ } \mu\text{g/kg/day}$$

The respiratory exposure **(without a respirator)** is:

Respiratory Exposure = 1.3 lb ai/day x 0.92 mg/lb ai x 1/70 kg
(mg/kg/day)

$$= 0.017 \text{ mg/kg/day} = 17 \text{ } \mu\text{g/kg/day}$$

Without a respirator:

$$\begin{aligned} \text{Total daily exposure (}\mu\text{g/kg/day)} &= 1.6 \text{ } \mu\text{g/kg/day} + 17 \text{ } \mu\text{g/kg/day} \\ &= 18.6 \text{ } \mu\text{g/kg/day} \end{aligned}$$

$$\begin{aligned} \text{Total annual exposure (}\mu\text{g/kg/day)} &= 220 \text{ days} \times 18.6 \text{ (}\mu\text{g/kg/day)} \\ &= 4092 \text{ } \mu\text{g/kg/yr} = 4.1 \text{ mg/kg/yr} \end{aligned}$$

With a respirator (offering 90 percent protection):

$$\begin{aligned} \text{Total daily exposure (}\mu\text{g/kg/day)} &= 1.6 \text{ } \mu\text{g/kg/day} + 1.7 \text{ } \mu\text{g/kg/day} \\ &= 3.3 \text{ } \mu\text{g/kg/day} \end{aligned}$$

$$\begin{aligned} \text{Total annual exposure (}\mu\text{g/kg/day)} &= 220 \text{ days} \times 3.3 \text{ (}\mu\text{g/kg/day)} \\ &= 726 \text{ } \mu\text{g/kg/yr} = 0.73 \text{ mg/kg/yr} \end{aligned}$$

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Table 3-2. Summary Statistics and Subset Specifications for Total Potential Dermal Exposure Derived from Phed V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Crack and Crevice or Indoor Broadcast Products Containing Chlorpyrifos and Wearing Long Pants, Long Sleeve Shirt, Gloves, and Shoes.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	1249.43	2636.0019	179.0708	1267.5067	16
NECK.FRONT	Lognormal	127.6425	756.6675	296.038	176.9167	16
NECK.BACK	Lognormal	120.1695	151.0809	73.0526	109.8324	16
UPPER ARMS	Lognormal	503.2845	494.7182	36.3833	463.0868	16
CHEST	Lognormal	613.9725	700.3928	71.0002	603.0781	16
BACK	Lognormal	613.9725	611.7981	38.4089	569.1622	16
FOREARMS	Lognormal	253.253	448.2142	146.8857	287.9792	16
THIGHS	Lognormal	1692.833	5126.2967	165.785	2440.9362	16
LOWER LEGS	Lognormal	435.064	458.983	52.9223	410.828	16
FEET						0
HANDS	Lognormal	1984.256	3430.9348	105.047	2284.9666	15
TOTAL DERM:	8614.2929	7593.8775	14815.0881		8614.2929	

95% C.I. on Mean: Dermal: [-150788.0621, 180418.2383]

Data File: MIXER/LOADER/APPLICATOR Number of Records: 16
 Subset Name: CRACK1.N.CREV.MLAP

Subset Specifications for CRACK.N.CREV.MLAP*

With Dermal Grade Uncovered Equal to "A" "B" "C"
 Subset originated from CRACK.N.CREV.MLAP
 With Study Code Equal to 458
 Subset originated from MLAP.FILE

*** Note second subset to examine hand exposure, selected with Hand Grade Equal to "A", yielded the exact same results and has not been included separately.**

Table 3-3. Summary Statistics and Subset Specifications for Total Potential Respiratory

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Exposure Derived from Phed V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Crack and Crevice or Indoor Broadcast Products Containing Chlorpyrifos and Wearing Long Pants, Long Sleeve Shirt, Gloves, and Shoes.

SUMMARY STATISTICS FOR INHALATION EXPOSURES

	DISTRIB. TYPE	Median	NANOGRAMS PER AVERAGE LB AI Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Lognormal	629140.98	1563494.331	119.722	916472.6463	16

95% C.I. on Geo. Mean: [121964.567, 6886607.5781]

Number of Records: 16

Data File: MIXER/LOADER/APPLICATOR

Subset Name: CRACK3.N.CREV.MLAP

Subset Specifications for CRACK3.N.CREV.MLAP

With Airborne Grade Equal to "A" "B" "C"

Subset originated from CRACK.N.CREV.MLAP

With Study Code Equal to 458

Subset originated from MLAP.FILE

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Table 3-4. Data from PHED v 1.1 to estimate the amount of active ingredient handled during a typical crack and crevice treatment of a home by a commercial applicator.

Record I.D.	Total US Gal Mixed	Total AI Mixed (lb)	Total US Gal Sprayed	Total AI Applied (lb)
0458*A*1	2.5000	0.1875	1.0000	0.0875
0458*A*2	1.0000	0.0875	0.9000	0.0812
0458*A*3	2.0000	0.1750	1.4000	0.1250
0458*A*4	1.7500	0.1563	1.0000	0.0890
0458*B*1	2.0000	0.1750	1.8000	0.1584
0458*B*2	0.5000	0.0438	1.0000	0.0875
0458*B*3	2.0000	0.1750	2.5000	0.2188
0458*B*4	3.0000	0.2625	2.5000	0.2188
0458*B*5	3.0000	0.2625	2.7500	0.2406
0458*B*6	2.0000	0.1750	1.5000	0.1313
0458*C*1	1.0000	0.0875	1.2500	0.1094
0458*C*2	1.0000	0.0875	1.1000	0.0937
0458*C*3	1.0000	0.0875	1.4000	0.1250
0458*C*4	2.0000	0.1750	1.2500	0.1094
0458*C*5	1.0000	0.0875	1.5000	0.1313
0458*C*6	1.0000	0.0875	1.5000	0.1313
MEAN	1.67	0.14	1.52	0.13

4.0 Post Application Exposure from Broadcast Treatment

The estimates of post-application exposure for broadcast treatment were obtained from a registrant submitted study that has previously been reviewed by OREB (2).

The study was designed to monitor the exposures of individuals performing activities on a carpet treated with 0.5 percent chlorpyrifos (Dursban LO). The purpose of the study was to extrapolate the exposures of infants from measurements taken from adult volunteers performing specified activities immediately after the carpet had dried.

The study measured total deposition of the insecticide using gauze patches and aluminum foil coupons. Total internal doses of six volunteers were measured directly using measurements of the metabolite 3,5,6-trichloro-2-pyridinol (3,5,6-TCP) in the urine. Extrapolation to total internal dose from urine monitoring was conducted using a pharmacokinetic model previously submitted to the Agency. OREB based its assessment on the assumption that this model is correct but emphasized that verification by Toxicology Branch was necessary.

Indirect estimates of exposure were also obtained by using air measurements, the amount of chlorpyrifos obtained by dragging a weighted patch over the carpet, and by hand rinses. A weighted patch (Dow Sled) was designed to simulate the amount of force applied by a one year old child. Transfer coefficients were obtained by this method and are presented in Table 4-1.

Total residues tended to dissipate within approximately 12 hours to a relatively constant level of about 4000 μg per ft^2 . It is unknown how long this level remains before additional dissipation occurs. OREB notes that, even though the total residues level off after about 12 hours, the transfer coefficients continued to decline over time. This may be due to increased binding of chlorpyrifos to the carpet material. The material is often applied several times per year, at uneven intervals. Labels do not specify an interval between applications or avoidance of the use of other chlorpyrifos products in the home environment. The decrease in transfer coefficient, even though absolute residue levels tend to remain fairly constant (and therefore insecticidally efficacious) for a period of time, indicates to OREB that the remaining residues probably contribute a negligible amount to the exposure that would occur following a subsequent application, assuming that a few days had passed between applications.

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Table 4-1. Transfer Coefficients Derived from Gauze Deposition Pads and Drag Sled Sampling of a Carpet Following Broadcast Treatment with 0.5 Percent Chlorpyrifos.

House	Room	Hrs After Drying	Avg Deposition		Avg Drag Transfer Coefficient	
			$\mu\text{g}/103\text{ cm}^2$	$\mu\text{g}/\text{ft}^2$	$\mu\text{g}/\text{ft}^2$	(=Avg Drag/Avg Dep.)
1	PC	0	861	7749		
		1	766	6894		
		2	974	8766	28.9	0.0033
		4	781	7029	29.3	0.0042
		8	632	5688	28.2	0.0050
		12	555	4995	17.3	0.0035
		24	457	4113	14.9	0.0036
		48	587	5283	8.6	0.0016
	Activ.	0	1052	9468		
		1	1186	10674		
		2	767	6903	26.6	0.0039
		8	623	5607	23.1	0.0041
		24	696	6264	30.5	0.0049
2	PC	0	575	5175		
		1	627	5643		
		2	407	3663	24.8	0.0068
		4	436	3924	15.1	0.0038
		8	280	2520	6.8	0.0027
		12	478	4302	6.8	0.0016
		24	488	4392	3.1	0.0007
		48	464	4176	1.5	0.0004
	Activ.	0	503	4527		
		1	337	3033		
		2	380	3420	49.3	0.0144
		8	548	4932	33.6	0.0068
		24	515	4635	16.9	0.0036
Mean					0.0042	

¹ PC = Physicochemical monitoring room in which no activity was performed.

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Airborne chlorpyrifos concentrations in all rooms monitored reached a maximum within 8 hours after application. Levels then dissipated to an average of approximately 0.5 µg/m³ after 24 hours (average of 1 physicochemical monitoring room and 1 activity room in each house). After 48 hours the level had decreased to an average of 0.26 µg/m³. These samples were measured in the physicochemical monitoring rooms only.

The registrant attempted to address the issue of possible exposure of children through hand/oral contact following contact with a treated surface. The volunteers' hands were washed and it was assumed that all of the material rinsed from the hands was available for oral ingestion. There are no quantitative data addressing the possible exposure via the hand/oral route currently available. OREB considers the approach used by the registrant to provide a reasonable estimate of exposure via this route.

OREB calculated exposures of individuals for the day of treatment and for the following day. Both the direct measurements and indirect estimates are presented in Table 4-2. The estimates derived from measurement of the metabolite 3,5,6-TCP in urine should probably be considered to be more accurate since fewer assumptions are required. OREB realizes that failure to adjust for surface area to body weight ratio introduces some error to the estimates but believes that this error is probably less than that resulting from the assumptions required to utilize the indirect measurements for exposure estimation.

Table 4-2. Estimates of the Exposures of Children to Chlorpyrifos Following Broadcast treatment of a Carpet with a 0.5 Percent Solution of Dursban LO.

Method	Exposure (µg/kg)	
	Day 1	Day 2
Direct	12	
(Biomonitoring)		
Hand/Oral	10	1.9
Total (Direct)	23	14 ¹
Indirect:		
Dermal	1.4	0.27
Respiratory	2.8	1.5
Hand Oral	10	1.9
Total (Indirect)	15	3.7

¹ Second day direct monitoring estimate is sum of second day estimated Hand/Oral exposure + Results of biological monitoring (specimens collected over several days) and should be considered to be conservative.

5.0 Adjustment of Post-Application Exposures from Broadcast Application for Crack and Crevice Treatment.

The estimates of exposures from treated carpet following broadcast application were derived from a study in which adult volunteers performed child-like activities on a carpet treated with 0.5 percent chlorpyrifos. Gauze pads were placed on the carpet prior to application and removed immediately after spraying was complete to determine deposition. The average deposition on these gauze pads, collected from eight rooms, was 6871 µg per ft. A crack and crevice treatment is more controlled and would be expected to yield much lower surface residues than other types of treatments. In order to adjust the surface residues from broadcast treatment to compensate for this difference, OREB used a study from the scientific literature.

CITATION: Leidy, R.B., C.G. Wright, and H.E. Dupree (1993)
Exposure Levels to Indoor Pesticides. IN: Pesticides
In Urban Environments American Chemical Society
Symposium 282.

This review cites a study in which chlorpyrifos and diazinon residues were measured on non-target surfaces following crack and crevice treatment. A maximum of 1.0 µg per cm² (929 µg per ft²) was detected on dosimeters placed on the floor in a non-target area. The ratio of the levels observed on untreated surfaces following broadcast and crack and crevice treatment is:

$$929 \text{ µg/ft}^2 \div 6871 \text{ µg/ft}^2 = 0.14$$

Therefore the expected residues would be about 14 percent of those observed from the broadcast study. Assuming that these residues are equally dislodgeable the exposures estimated in the broadcast study should be decreased by 86 percent to account for the difference in surface residues. OREB used this correction to estimate the post-application exposure that would result from crack and crevice treatment (0.012 mg/kg/day for adults and 0.023 mg/kg/day for children). The resulting exposures on the day of treatment were 0.0017 and 0.0032 mg per kg per day for adults and children, respectively. Exposures of children on the day after treatment was extrapolated to be 0.0020 mg per kg per day.

6.0 Application of Chlorpyrifos Dust Products

OREB has no data addressing the potential exposures of persons using dust products containing chlorpyrifos. The estimates were derived from a surrogate study in which a 5 percent carbaryl dust was applied using a shaker can to corn and beans in a residential setting (3, described in detail in Appendix A.). While there may be dust products with slightly different percentages of active ingredient, OREB has based its assessment on the 5 percent product.

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Applicators dispensed 190 to 220 g of the dust product (9.5-11 g ai or 0.021-0.024 lb ai) to either corn or beans. Measurements were taken of the **total deposition** of the material on the skin/clothing surfaces. The product was applied for 15 minutes, enough time to treat an average home garden. The total potential dermal exposure, measured using **total deposition** was 11 mg per 15 minute treatment (44 mg/hr or 5.0×10^3 mg/lb ai).

There are no data adequate to determine the amount of protection that clothing offers to dust formulations. It was assumed that areas covered by clothing offer 50 percent protection and that gloves offer 90 percent protection, probably a highly conservative assumption considering the nature of dust products. A one percent dermal absorption of the active ingredient was used in the calculations (1). The estimated exposures for individuals based on total deposition, wearing long pants, long sleeves, and gloves; and long pants, short sleeves with no gloves, are presented in Table 6-1.

Table 6-1. Estimates of Dermal Exposures of Residents Applying a 5 Percent Formulation of Chlorpyrifos Dust. Applicators are assumed to weigh 70 kg and have a one percent dermal absorption. Clothing is assumed to offer 50 percent protection and gloves 90 percent (a very conservative assumption).

Clothing Scenario	mg/15 min	mg/kg/15 min	mg/hr	mg/kg/hr	mg/lb ai	mg/kg/lb ai
Total Deposition (No clothing)	11	0.002	44	0.006	5.0×10^3	0.71
Long sleeves, long pants, gloves	4.5	0.001	18	0.003	2.0×10^3	0.29
Short sleeves, long pants, no gloves	4.9	0.001	20	0.003	2.2×10^3	0.31

7.0 Termiticide Treatment Applicator Exposures

OREB has derived daily and annual exposures of termiticide applicators using data from the Pesticide Handlers Exposure Database (PHED), Version 1.1. Use information was obtained from data were provided in an air monitoring study submitted by Dow Chemical Company measuring air concentrations of chlorpyrifos in homes treated for subterranean termite control (4). The average amount of material applied to the 32 test homes was used to estimate the amount applied to an average home. This average amount handled per day was 8.2 lbs ai per treatment. The data used to obtain this information are presented in Table 7-1.

The summary statistics for termiticide use from PHED V1.1 for termiticide use are presented in Tables 7-2 and 7-3 for the dermal and respiratory routes, respectively. The scenario assumes that the same worker performs the mixing/loading and application tasks and that the workers wear long sleeves, long sleeved shirts and gloves.

Several additional assumptions were required to derive daily and annual exposures of these workers:

1. An average worker weighs 70 kg and has a respiratory volume of 25 liters per minutes, used as the default value in PHED.
2. One home is treated per day.
3. Since termiticide application is usually performed by a team, each member of which may perform several functions, each is assumed to perform mixer/loader and application tasks.
4. An average commercial applicator works 220 days per year.
5. The dermal absorption of chlorpyrifos is 1 percent (1).

The dermal exposure estimate of termiticide workers, obtained from PHED was 360 µg per pound of active ingredient (lb ai). The geometric mean respiratory exposure is 1.9 µg per lb ai.

The potential daily dermal exposure then becomes:

$$\begin{aligned}\text{Exposure } (\mu\text{g/kg/day}) &= 360 \mu\text{g/lb ai} \times 8.2 \text{ lb ai/day} \times 1/70 \text{ kg} \\ &= 42 \mu\text{g/kg/day}\end{aligned}$$

Multiplying by the percent absorption (1%) the **Daily Dermal Exposure** is:

$$= 0.42 \mu\text{g/kg/day}$$

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Daily Respiratory Exposure:

$$\begin{aligned}\text{Exposure } (\mu\text{g/kg/day}) &= 1.9 \mu\text{g/lb ai} \times 8.2 \text{ lb ai/day} \times 1/70 \text{ kg} \\ &= 0.22 \mu\text{g/kg/day}\end{aligned}$$

The total daily exposure is:

$$\begin{aligned}\text{Total daily exposure } (\mu\text{g/kg/day}) &= 0.42 \mu\text{g/kg/day} + 0.22 \mu\text{g/kg/day} \\ &= 0.64 \mu\text{g/kg/day}\end{aligned}$$

The total annual exposure is:

$$\begin{aligned}\text{Annual exposure } (\mu\text{g/kg/yr}) &= 220 \text{ days/yr} \times 0.64 \mu\text{g/kg/day} \\ &= 141 \mu\text{g/kg/yr}\end{aligned}$$

Table 7-1. Calculation of the amount of chlorpyrifos handled by termiticide applicators during a typical work day. Data are based on a study conducted by Dow Chemical Company (3).

HOUSE	CONC. (%)	VOL. (gal)	GAL. PRODUCT USED	LBS USED
B1	0.9	85	1.5	6.0
B2	1.0	65	1.3	5.2
B3	1.0	186	3.7	14.8
B4	1.0	175	3.5	14.0
B5	1.0	180	3.6	14.4
B6	0.8	170	2.7	10.8
B7	0.8	185	3.0	12.0
B8	0.7	170	2.4	9.6
C1	1.2	104	2.5	10.0
C2	1.0	105	2.1	8.4
C3	0.9	203	3.7	14.8
C4	1.0	129	2.6	10.4
C5	1.1	170	3.7	14.8
C6	1.3	130	3.4	13.6
C7	0.8	43	0.7	2.8
C8	0.8	45	0.7	2.8
P1	0.8			
P2	0.8	200	3.2	12.8
P3	0.9	35	0.6	2.4
P4	0.9			
P5	1.0	125	2.5	10.0
P6	1.0	100	2.0	8.0
P7	1.0	60	1.2	4.8
P8	0.8	90	1.4	5.6
S1	0.6	80	1.0	4.0
S2	0.8	98	1.6	6.4
S3	0.9	95	1.7	6.8
S4	0.8	50	0.8	3.2
S5	0.8	50	0.8	3.2
S6	0.9	50	0.9	3.6
S7	0.9	60	1.1	4.4
S8	0.9	75	1.4	5.6
			MEAN	8.2

lbs ai used = 4 lbs/gal x Conc (%) x Vol (gal) x 2 gal/100 gal
finished spray for 1%

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Table 7-2. Summary Statistics and Subset Specifications for Total Potential Dermal Exposure Derived from PHED V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Chlorpyrifos for Subterranean Termite Control. Workers are Assumed to be Wearing Long Pants, Long Sleeve Shirt, Gloves, and Shoes.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, gloves						
PATCH	DISTRIB.	MICROGRAMS		PER AVERAGE	LB AI	
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	13.91	81.6171	176.1534	16.2653	17
NECK.FRONT	Lognormal	11.055	316.4232	315.0398	14.0868	17
NECK.BACK	Lognormal	.528	1.7839	175.6657	.6259	17
UPPER ARMS	Lognormal	5.529	9.7228	101.2424	5.6498	17
CHEST	Lognormal	7.81	13.4274	110.0429	7.7291	17
BACK	Lognormal	3.905	6.9538	91.0926	4.3841	17
FOREARMS	Lognormal	8.833	16.6838	102.2351	9.714	17
THIGHS	Lognormal	122.24	768.7862	188.4758	162.7054	17
LOWER LEGS	Lognormal	46.172	52.374	77.4787	36.2681	17
FEET						0
HANDS	Lognormal	129.3333	253.5647	114.8682	102.5659	17
TOTAL DERM:	359.9944	349.3153	1521.3369		359.9944	

95% C.I. on Mean: Dermal: [-25374.1224, 28416.7962]

Data File: MIXER/LOADER/APPLICATOR Number of Records: 17
 Subset Name: TERMITICIDE1.MLAP

Subset Specifications for TERMITICIDE1.MLAP

With Dermal Grade Uncovered Equal to "A" "B"
 Subset originated from TERMITICIDES.MLAP
 With Study Code Equal to 0512 0513
 Subset originated from MLAP.FILE

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Table 7-3. Summary Statistics and Subset Specifications for Total Potential Respiratory Exposure Derived from PHED V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Chlorpyrifos for Subterranean Termite Control.

SUMMARY STATISTICS FOR INHALATION EXPOSURES

	DISTRIB. TYPE	Median	MEAN	COEF OF VAR	Geo. Mean	Obs.
EXPOSURE	Lognormal	1645.2991	2615.5647	93.9712	1893.723	17

95% C.I. on Geo. Mean: [389.6126, 9204.4941]

Number of Records: 17

Data File: MIXER/LOADER/APPLICATOR

Subset Name: TERMITICIDE3.MLAP

Subset Specifications for TERMITICIDE3.MLAP

With Airborne Grade Equal to "A"

Subset originated from TERMITICIDE.MLAP

With Study Code Equal to 0512 0513

Subset originated from MLAP.FILE

8.0 Paintbrush Application

OREB has derived daily and annual exposures of applicators using paintbrushes from data located the Pesticide Handlers Exposure Database (PHED), Version 1.1. Selection of paintbrush application yielded a subset with 15 replicates from a single study with data grades of C or better for hand, dermal uncovered, and respiratory measurements. Two scenarios were evaluated; one assuming the workers wear long sleeves, long sleeved shirts and no gloves; and the other assuming short sleeves, long pants and no gloves. The summary statistics for these scenarios are presented in Tables 8-1 and 8-2, respectively. OREB has no usage information addressing the amount of paint that might be applied on a given day. Therefore, OREB calculated exposures and MOEs on the basis of time using an assumption of an 8 hour work day. The daily exposures for a 70 kg worker wearing a long sleeve shirt, long pants, and no gloves would be:

$$\begin{aligned}\text{Dermal Exposure (mg/kg/day)} &= \frac{7.8 \text{ mg}}{\text{hr}} \times \frac{8 \text{ hrs}}{\text{day}} \times 0.01 \times \frac{1}{70 \text{ kg}} \\ &= 0.0089 \text{ mg/kg/day}\end{aligned}$$

$$\begin{aligned}\text{Respiratory (mg/kg/day)} &= \frac{0.012 \text{ mg}}{\text{hr}} \times \frac{8 \text{ hrs}}{\text{day}} \times \frac{1}{70 \text{ kg}} \\ &= 0.0014 \text{ mg/kg/day}\end{aligned}$$

$$\text{Total exposure (mg/kg/day)} = 0.010 \text{ mg/kg/day}$$

The corresponding exposure of a worker wearing short sleeve shirt, long pants, with no gloves would be 0.013 mg/kg/day.

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Table 8-1. Summary Statistics and Subset Specifications for Total Potential Respiratory Exposure Derived from PHED V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Chlorpyrifos Using Paintbrushes. Clothing consists of long pants and long sleeves with no gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, long sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS PER HOUR SAMPLE TIME				
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	87.88	314.0453	150.888	85.1385	15
NECK.FRONT	Lognormal	22.485	116.589	207.5796	21.3863	15
NECK.BACK	Lognormal	.649	2.2865	144.8196	1.0605	15
UPPER ARMS	Lognormal	11.058	28.8672	174.8458	14.571	15
CHEST	Lognormal	13.49	150.5673	215.1978	28.5359	15
BACK	Other	8.165	48.493	203.6393	15.1905	15
FOREARMS	Lognormal	138.666	373.3899	204.8483	116.5704	15
THIGHS	Lognormal	8.786	9.7792	34.5877	9.2877	15
LOWER LEGS	Lognormal	5.474	6.0928	34.5867	5.7866	15
FEET						0
HANDS	Lognormal	7569.2308	9086.2568	62.1302	7603.7741	15
TOTAL DERM:	7894.276	7865.8838	10136.367		7901.3015	
INHALATION:	Lognormal	11.5385	12.8877	34.5601	12.2423	15
COMBINED:	7906.5183	7877.4223	10149.2547		7913.5438	
95% C.I. on Mean: Dermal: [-81593.554, 101866.288]						
95% C.I. on Geo. Mean: Inhalation: [6.4658, 23.1795]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 15			
Data File: APPLICATOR			Subset Name: PAINTBRUSH.APPL			

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Table 8-2. Summary Statistics and Subset Specifications for Total Potential Respiratory Exposure Derived from PHED V 1.1 to Estimate the Potential Dermal and Respiratory Exposures of Individuals Applying Chlorpyrifos Using Paintbrushes. Clothing consists of long pants and short sleeves with no gloves.

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES						
SCENARIO: Long pants, short sleeves, no gloves						
PATCH	DISTRIB.	MICROGRAMS PER HOUR SAMPLE TIME				
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	87.88	314.0453	150.888	85.1385	15
NECK.FRONT	Lognormal	22.485	116.589	207.5796	21.3863	15
NECK.BACK	Lognormal	.649	2.2865	144.8196	1.0605	15
UPPER ARMS	Lognormal	11.058	28.8672	174.8458	14.571	15
CHEST	Lognormal	13.49	150.5673	215.1978	28.5359	15
BACK	Other	8.165	48.493	203.6393	15.1905	15
FOREARMS	Normal	1233.4135	2434.3904	130.6151	839.3122	14
THIGHS	Lognormal	8.786	9.7792	34.5877	9.2877	15
LOWER LEGS	Lognormal	5.474	6.0928	34.5867	5.7866	15
FEET						0
HANDS	Lognormal	7569.2308	9086.2568	62.1302	7603.7741	15
TOTAL DERM:	10212.096	8960.6313	12197.3675		8624.0433	
INHALATION:	Lognormal	11.5385	12.8877	34.5601	12.2423	15
COMBINED:	10224.3383	8972.1698	12210.2552		8636.2856	
95% C.I. on Mean: Dermal: [-92868.4679, 117263.2029]						
95% C.I. on Geo. Mean: Inhalation: [6.4658, 23.1795]						
Inhalation Rate : 25 Liters/Minute			Number of Records: 15			
Data File: APPLICATOR			Subset Name: PAINTBRUSH.APPL			

9.0 Spray Application to Turf

OREB used an exposure study submitted by the registrant to estimate exposures of individuals applying chlorpyrifos using lawn-care spray apparatus. The study was reviewed in January 1990 (5, described in detail in Appendix B.). The exposures are summarized in Table 9-1.

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Table 9-1. Summary of Exposures of Workers to Chlorpyrifos (Dursban) Applied to Turf Using Hand-Held Power Spray Equipment.

	Long sleeves, no gloves	Long sleeves, gloves	Short Sleeves no gloves	Short sleeves gloves	Respiratory
mg/hr	44.84	27.81	58.00	41.00	3.3×10^{-3}
mg/day	224.19	139.07	290.00	205.00	1.7×10^{-2}
mg/kg/hr	0.64	0.40	0.83	0.59	4.7×10^{-5}
mg/kg/day	3.20	1.99	4.1	2.93	2.4×10^{-4}

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REFERENCES

- 1) Memorandum from A. Levy (TB-I) to L. Propst (SRRD) titled "CHLORPYRIFOS - Human Oral and Dermal Absorption", dated March 6, 1995.
- 2) Memorandum from D. Jaquith (OREB) to D. Edwards (RD) titled "Review of Study Measuring Indoor Levels of and Exposure to Chlorpyrifos Following Carpet Treatment", dated August 18, 1995.
- 3) Kurtz, D.A. and W.M. Bode (1985) Application Exposure to the Home Gardener IN: Dermal Exposure Related to Pesticide Use American Chemical Society Symposium Series 273, R.C. Honeycutt, G. Zweig, and N.N. Ragsdale Eds, American Chemical Society , Washington, D.C.
- 4) Vaccaro, J., R. Bohl, B. Skowronski, and P. Moribito (1987) Airborne Chlorpyrifos Concentrations Measured During and Following Applications of DURSABAN TC Insecticide to Residential Dwellings. Dow Chemical Report GH-P 1310.
- 5) Memorandum from D. Jaquith (NDEB) to D. Edwards (RD) titled "Re-Evaluation of Chlorpyrifos Lawn Care Exposure Study (HED Project No. 9-0609), dated January 10, 1990.

cc: Correspondence file
J. Redden (RCAB/7509C)
D. Jaquith (OREB/7509C)

APPENDIX A

CITATION: Kurtz, D.A. and W.M. Bode (1985) Application Exposure to the Home Gardener IN: Dermal Exposure Related to Pesticide Use American Chemical Society Symposium Series 273, R.C. Honeycutt, G. Zweig, and N.N. Ragsdale Eds, American Chemical Society , Washington, D.C.

Dermal exposure of home gardeners was monitored during application of the insecticide carbaryl. The investigation included evaluation of dust, wettable powder, and aqueous suspension formulations containing 5, 50, and 43 percent active ingredient, respectively. The dust was applied using either a shaker or a dust pump. The wettable powder and aqueous suspension were both applied using hand held pressurized tank equipment. The insecticide was applied to two representative crops, corn (1.0-1.3 m height) and beans (0.2-0.3 m high).

Applicators were volunteers selected from the community. The volunteers were told to apply the pesticide according to the label instructions. Each applied all three formulations to corn and/or beans. A total of 24 replicates, 12 with each crop, were monitored for each formulation. An exposure replicate included filling the unit, applying the compound, and emptying the equipment after treatment. Fifteen minutes, timed by an observer, were allowed for each replicate. Two of the treatments with dust were conducted using a ready-to-use shaker can. One tablespoon of the wettable powder or aqueous suspensions was used with one gallon of water in the compressed air sprayers.

Dermal exposure of the body was measured using gauze pads attached to the outside of a Tyvek suit. A description of the patch locations is presented in Table A-1. Dermal exposure of the hands was measured by hand rinse with 200 ml of 0.03% NaOH in ethanol. A 20 ml aliquot was selected for analysis. Twenty milliliter samples were also collected from the spray wand before and after application to confirm the amount of active ingredient handled. The mean amounts of active ingredient applied during the treatments are presented in Table A-2.

The pads were extracted with methanol containing 0.03 percent NaOH. Ethanol was used in the hand washes to avoid the toxicity problems that could arise with methanol. Samples were analyzed within 6 hours of collection to minimize breakdown of carbaryl. Recoveries from six gauze pads, fortified in the field at levels of 10 µg and 50 µg, were 101 and 98 percent, respectively. Similar recoveries from ethanol solutions spiked at 50 and 200 µg levels were 144 and 189 percent, respectively.

Dermal exposures were estimated for clothing scenarios ranging from no protection from clothing to long sleeves and long pants

(50% protection) with gloves (90% protection). These values are presented in Tables A-3 and A-4, for dust and liquid applications, respectively. Due to the similarities in the exposure scenarios and the data obtained the results of the trials with the wettable powder and aqueous suspension were averaged before exposure calculations were conducted. The assumption of 50 percent protection from clothing is probably very conservative in the case of the dust formulation. Respiratory exposure was not measured. The underlying assumption was that clothing offered complete protection to covered areas. The residue levels found on dermal pads or on the hands are presented in Tables A-5 to A-7.

Table A-1. Body Areas Monitored for Dermal Exposure to Carbaryl During Home Garden Application.

Body Part	Pad Location/ Dosimeter	Pad Area (cm ²)
Face, front of neck	Face mask	120
Shoulder, upper arms	Top of shoulders	50
Back	Upper back	25
Chest	Upper chest	25
Forearms	Forearms	25 each
Hand	Hand wash	Entire hand
Thigh	Thighs	25 each
Lower leg	Cuff	25 each
Ankle	Shoe vamps	2.5 each ¹
Foot	Top of feet	25 each

¹ Area for exposure calculation, hidden area = 22.5 cm²

Table A-2. Mean Amounts of Carbaryl Applied to Gardens in 15 Minutes

Formulation	Crop	Formulation	Amount Applied Active Ingredient	(g)
Dust	Corn	190	g	9.5
	Beans	220	g	11
Wettable powder	Corn	2.8	L	2.1
	Beans	2.9	L	2.8
Aqueous suspension	Corn	2.8	L	3.2
	Beans	2.9	L	3.0

Table A-3. Potential Dermal Exposures of Home Gardeners to a Dust Formulation of Carbaryl in 15 minutes of treatment.

Body Part	Clothing Factor	Surface Area (cm ²)	Dermal Exposure (micrograms)		
			No Protection	Long sleeves, gloves	Short sleeves no gloves
Face	1.0	1300	660	660	660
Shoulders	0.5	2910	361	180	180
Back	0.5	3550	483	241	241
Chest					
Right	0.5	1775	533	266	266
Left	0.5	1775	422	211	211
Forearms					
Right	0.5	605	215	108	215
Left	0.5	605	120	60	120
Hands					
Right	0.9	410	128	13	128
Left	0.9	410	108	11	108
Thighs					
Right	0.5	1910	680	340	340
Left	0.5	1910	1131	565	565
Lower leg					
Right	0.5	1190	1380	690	690
Left	0.5	1190	1833	916	916
Shoe					
Right	0.9	655	1179	118	118
Left	0.9	655	1376	138	138
TOTAL DERMAL EXPOSURE (µg/15 min.)			1.1×10^4	4.5×10^3	4.9×10^3
µg per hr:			4.4×10^4	1.8×10^4	2.0×10^4
Mean g ai handled:			1.0	1.0	1.0
µg per lb ai:			5.0×10^6	2.0×10^6	2.2×10^6
mg per lb ai:			5.0×10^3	2.0×10^3	2.2×10^3

Table A-4. Potential Dermal Exposures of Home Gardeners to Wettable Powder and Aqueous Suspension Formulations of Carbaryl.

Body Part	Surface Area	Clothing Factor	Wettable Powder	Aqueous Suspension	Mean (No Protection)	Long sleeves, gloves	Short sleeves no gloves
Face	1300	0.0	138	101	120	120	120
Shoulders	2910	0.5	169	239	204	102	102
Back	3550	0.5	256	873	565	282	282
Chest							
Right	1775	0.5	96	167	132	66	66
Left	1775	0.5	170	121	146	73	73
Forearms							
Right	605	0.5	28	120	74	37	74
Left	605	0.5	70	115	93	46	93
Hands							
Right	410	0.9	43	30	37	4	37
Left	410	0.9	33	32	33	3	33
Thighs							
Right	1910	0.5	871	1039	955	478	478
Left	1910	0.5	737	1039	888	444	444
Lower leg							
Right	1190	0.5	1095	1833	1464	732	732
Left	1190	0.5	1214	1476	1345	673	673
Shoe							
Right	655	0.9	996	1127	1062	106	106
Left	655	0.9	891	1205	1048	105	105
TOTAL DERMAL EXPOSURE ($\mu\text{g}/15 \text{ min.}$)					8.2×10^3	3.3×10^3	3.4×10^3
$\mu\text{g per hr.}$					3.3×10^4	1.2×10^4	1.4×10^4
Mean g ai handled:					2.8	2.8	2.8
$\mu\text{g per lb ai.}$					1.3×10^6	5.4×10^5	5.5×10^5
mg per lb ai:					1.3×10^3	5.4×10^2	5.5×10^2

Table A-5. Potential Dermal Exposures of Individuals to Carbaryl Dust Applied to Home Gardens. No Protection from Clothing is Assumed.

Body Part	Surface Area (cm ²)	µg found ¹	Corn Exposure (µg)	µg found ¹	Beans Exposure (µg)	Mean for Both Crops
Face	1300	14.9	775	10.5	546	660
Shoulders	2910	3.3	384	2.9	338	361
Back	3550	3.2	454	3.6	511	483
Chest						
Right	1775	9.2	653	5.8	412	533
Left	1775	8.0	568	3.9	277	422
Forearms						
Right	605	14.2	344	3.6	87	215
Left	605	4.4	106	5.5	133	120
Hands						
Right	410	11.8	194	3.8	62	128
Left	410	7.9	130	5.3	87	108
Thighs						
Right	1910	13.2	1008	4.6	351	680
Left	1910	24.0	1834	5.6	428	1131
Lower leg						
Right	1190	22.0	1047	36.0	1714	1380
Left	1190	25.0	1190	52.0	2475	1833
Shoe						
Right	655	37.0	969	53.0	1389	1179
Left	655	39.0	1022	66.0	1729	1376
<hr/>						
TOTAL DERMAL EXPOSURE (µg/15 minutes):			1.1 x 10 ⁴		1.1 x 10 ⁴	1.1 x 10 ⁴
µg/hr:			4.4 x 10 ⁴		4.4 x 10 ⁴	4.4 x 10 ⁴
mean µg handled:			9.5		11	10
µg/lb ai			5.3 x 10 ⁵		4.5 x 10 ⁵	5.0 x 10 ⁵
mg/lb ai			5.3 x 10 ²		4.5 x 10 ²	5.0 x 10 ²

¹ µg found, adjusted to a 25 cm² dosimeter.

Table A-6. Potential Dermal Exposures of Individuals to a Wettable Powder Formulation. No Protection from Clothing is Assumed.

Body Part	Surface Area (cm ²)	µg found ¹	Corn Exposure (µg)	µg found ¹	Beans Exposure (µg)	Mean for Both Crops
Face	1300	2.8	146	2.5	130	138
Shoulders	2910	1.9	221	1.0	116	169
Back	3550	1.9	270	1.7	241	256
Chest						
Right	1775	1.8	128	0.9	64	96
Left	1775	3.8	270	1.0	71	170
Forearms						
Right	605	1.6	39	0.7	17	28
Left	605	5.2	126	0.6	15	70
Hands						
Right	410	3.0	49	2.2	36	43
Left	410	2.7	44	1.3	21	33
Thighs						
Right	1910	22.0	1681	0.8	61	871
Left	1910	17.0	1299	2.3	176	737
Lower leg						
Right	1190	12.0	571	34.0	1618	1095
Left	1190	23.0	1095	28.0	1333	1214
Shoe						
Right	655	32.0	838	44.0	1153	996
Left	655	40.0	1048	28.0	734	891
TOTAL DERMAL EXPOSURE (µg/15 minutes):			7.8 × 10 ³		5.8 × 10 ³	6.8 × 10 ³
µg/hr:			3.1 × 10 ⁴		2.3 × 10 ⁴	2.7 × 10 ⁴
mean µg handled:			2.1		2.8	2.5
µg/lb ai			1.7 × 10 ⁶		9.4 × 10 ⁵	1.3 × 10 ⁶
mg/lb ai			1.7 × 10 ³		9.4 × 10 ²	1.3 × 10 ³

¹ µg found, adjusted to a 25 cm² dosimeter.

Table A-7. Potential Dermal Exposures of Individuals to an Aqueous Suspension For No Protection from Clothing is Assumed.

Body Part	Surface Area (cm ²)	µg found ¹	Corn Exposure (µg)	µg found ¹	Beans Exposure (µg)	Mean for Both Crops
Face	1300	1.9	99	2.0	104	101
Shoulders	2910	1.4	163	2.7	314	239
Back	3550	10.6	1505	1.7	241	873
Chest						
Right	1775	3.9	277	0.8	57	167
Left	1775	2.0	142	1.4	99	121
Total	3550	5.9	419	2.2	156	288
Forearms						
Right	605	9.1	220	0.8	19	120
Left	605	8.7	211	0.8	19	115
Total	1210	17.8	431	1.6	39	235
Hands						
Right	410	2.2	36	1.4	23	30
Left	410	2.4	39	1.5	25	32
Total	820	4.6	75	2.9	48	62
Thighs						
Right	1910	26.0	1986	1.2	92	1039
Left	1910	22.0	1681	5.2	397	1039
Total	3820	48.0	3667	6.4	489	2078
Lower leg						
Right	1190	39.0	1856	38.0	1809	1833
Left	1190	28.0	1333	34.0	1618	1476
Total	2380	67.0	3189	72.0	3427	3308
Shoe						
Right	655	41.0	1074	45.0	1179	1127
Left	655	41.0	1074	51.0	1336	1205
Total	1310	82.0	2148	96.0	2515	2332
TOTAL DERMAL EXPOSURE (µg/15 minutes):			1.2 x 10 ⁴		7.3 x 10 ³	9.5 x 10 ³
µg/hr:			4.8 x 10 ⁴		2.9 x 10 ⁴	3.9 x 10 ⁴
mean µg handled:			3.2		3.0	3.1
µg/lb ai			1.7 x 10 ⁶		1.1 x 10 ⁶	1.4 x 10 ⁶
mg/lb ai			1.7 x 10 ³		1.1 x 10 ³	1.4 x 10 ³

¹ µg found, adjusted to a 25 cm² dosimeter.

APPENDIX B

CITATION: Vaccaro, J.R. (1986) Evaluation of Airborne and Whole Body Exposure of Lawn Care Specialists to Chlorpyrifos During Routine Treatment of Turf. Accession No. 400260-01.

Exposures of the potential dermal and respiratory exposures of lawn care pest control operators to chlorpyrifos were measured during the application of the insecticide to residential turf. The material was applied, at the normal industry application concentrations (0.07-0.1 percent), using power hose end sprayers attached to reservoirs located on trucks. Spray tank mix concentrations were not reported.

Exposures were monitored during twelve applications, 2 each with 6 different workers. Each application cycle consisted of a work period of approximately 30 minutes of actual spray time. Spray time was defined as the time the hose was uncoiled to the time the hose was rewound onto the truck. Exposures during the mixing/loading procedure were not measured. Dermal exposure of the body was monitored using 2 inch by 2 inch gauze patches, located outside of the clothing, on the sternum, groin, thighs (front and back), and calves (also front and back). Dermal exposure of the hands was measured using cotton gloves. No protective gloves were reported to be worn during this study. Respiratory exposure concentrations were measured by drawing air through glass tubes, at a rate of 200 cc per minute, using calibrated personal sampling pumps. Chromosorb 102 was used as the trapping agent. The dosimeters were used for a 30 minute work period, after which they were replaced by a second series for the next trial. The dosimeters were desorbed with hexane and residues quantified by gas chromatography using an electron capture detector.

CALCULATION OF EXPOSURES

The study design included dermal dosimeters at 10 different locations on the body. Patches on the back and arms were not included as recommended by the Pesticide Assessment Guidelines - Subdivision U. These omissions required additional extrapolations in order to estimate exposures to these body areas. The assumptions used by OREB to estimate exposures of these workers are presented below:

- 1) Workers are assumed to weigh 70 kg and have standard surface areas as presented in the Pesticide Assessment Guidelines - Subdivision U.

- 2) Gloves are assumed to offer 90 percent protection to the hands. Fifty percent protection is assumed for other areas covered by clothing. Four different clothing scenarios were examined in this assessment; assuming the wearing of either long or short sleeve shirt, and with or without gloves.
- 3) Workers are assumed to have a respiratory volume of 1.7 m³ per hour while applying the pesticide.
- 4) Dermal exposures are not corrected for dermal absorption.
- 5) Chlorpyrifos is applied for 5 hours per day.

In order to adjust for missing dosimeters on the arms and back, the reviewer used values from existing dosimeters for estimation of exposures to these areas.

Hand Exposure

The values measured on the hands were used to estimate each forearm exposure. The equation used is:

$$\text{Forearm Exposure } (\mu\text{g}) = \frac{\text{Hand Exposure } (\mu\text{g})}{410 \text{ cm}^2} \times 605 \text{ cm}^2$$

Upper Arm Exposure

The mean of the sternum pad and hand values was used to calculate upper arm exposures. The equation used for estimation of the exposure each upper arm is:

$$\text{Upper Arm Exposure } (\mu\text{g}) = \frac{\text{Mean of Sternum and Hand } (\mu\text{g})}{\text{Patch surface area } (\text{cm}^2)} \times 1455 \text{ cm}^2$$

Back Exposure

Exposure of the back was estimated by adjusting the values obtained from the chest measurement (mean of sternum pad and groin pad) by the ratio of the residues measured on the front and back of the legs. The correction factor is:

$$\text{CF} = \frac{(\text{Sum of exposures on back of legs, both calves and thighs})}{(\text{Sum of exposures on front of legs, both calves and thighs})}$$

The mean value of the chest and groin patches was then calculated. This value was then adjusted by the correction factor, CF. The equation used for estimation of back exposure was:

$$\text{Back exposure } (\mu\text{g}) = \frac{\text{Mean of Sternum and Groin pads } (\mu\text{g})}{\text{Patch Surface Area } (\text{cm}^2)} \times \text{CF} \times 3550 \text{ cm}^2$$

The mean dermal exposures of the applicators for the four clothing scenarios are presented in Tables B-1 to B-4.

Respiratory Exposure

The estimated respiratory exposures of these workers are presented in Table B-5. It was assumed that the workers have a respiratory volume of 1.7 m³ per hour. Exposure was calculated for the spray time only, the contribution due to air levels in the truck were not included.

Table B-1. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear long sleeve shirts, long pants, and no gloves.

Body Area	Surface Area (cm ²)	Clothing Factor	µg per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted (µg)	(µg/hr)	Adjusted for Clothing (µg)	(µg/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8 ¹	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	0.5	NA ²	28.4	2100	3426	1050	1713
Right Forearm	605	0.5	NA	28.4	11207	23683	5604	11841
Left Hand	410	1.0	NA	28.4	1423	2914	1423	2914
Right Hand	410	1.0	NA	28.4	7595	16001	7595	16001
TOTAL DERMAL EXPOSURE					34103	70751	21564	44837

¹ Extrapolated from chest values and ratio of residues on front and back of legs.

² Not Applicable. No dosimeter used, exposure based on hand value.

Table B-2. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear long sleeve shirts, long pants, and gloves.

Body Area	Surface Area (cm ²)	Clothing Factor	µg per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted (µg)	Unadjusted (µg/hr)	Adjusted for Clothing (µg)	Adjusted for Clothing (µg/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8 ¹	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	0.5	NA ²	28.4	2100	3426	1050	1713
Right Forearm	605	0.5	NA	28.4	11207	23683	5604	11841
Left Hand	410	0.1	NA	28.4	1423	2914	142	291
Right Hand	410	0.1	NA	28.4	7595	16001	760	1600
TOTAL DERMAL EXPOSURE					34103	70751	13448	27813

¹ Extrapolated from chest values and ratio of residues on front and back of legs.

² Not Applicable. No dosimeter used, exposure based on hand value.

Table B-3. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear short sleeve shirts, long pants, and no gloves.

Body Area	Surface Area (cm ²)	Clothing Factor	µg per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted (µg)	Unadjusted (µg/hr)	Adjusted for Clothing (µg)	Adjusted for Clothing (µg/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8 ¹	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	1.0	NA ²	28.4	2100	3426	2100	3426
Right Forearm	605	1.0	NA	28.4	11207	23683	11207	23683
Left Hand	410	1.0	NA	28.4	1423	2914	1423	2914
Right Hand	410	1.0	NA	28.4	7595	16001	7595	16001
TOTAL DERMAL EXPOSURE					34103	70751	28217	58392

¹ Extrapolated from chest values and ratio of residues on front and back of legs.

² Not Applicable. No dosimeter used, exposure based on hand value.

Table B-4. Dermal Exposures of Workers Applying Chlorpyrifos (Dursban) to Turf Using Powered Hand-Spray. Workers are assumed to wear short sleeve shirts, long pants, and gloves.

Body Area	Surface Area (cm ²)	Clothing Factor	µg per patch	Spray Time (min)	Dermal Exposure			
					Unadjusted (µg)	Unadjusted (µg/hr)	Adjusted for Clothing (µg)	Adjusted for Clothing (µg/hr)
Front of Neck	110	1.0	0.75	28.4	3.2	6.8	3.2	6.8
Chest	1775	0.5	0.75	28.4	52	109	26	55
Groin	1775	0.5	4.0	28.4	278	607	139	303
Back	3550	0.5	1.8	28.4	243	512	122	256
Left Thigh Front	562.5	0.5	39	28.4	850	1725	425	863
Right Thigh Front	562.5	0.5	29	28.4	625	1357	312	678
Right Thigh Back	562.5	0.5	28	28.4	601	1267	300	634
Left Calf Front	595	0.5	135	28.4	3105	6567	1553	3283
Left Calf Back	595	0.5	27	28.4	623	1300	312	650
Right Calf Front	595	0.5	186	28.4	4290	8954	2145	4477
Right Calf Back	595	0.5	19	28.4	446	932	223	466
Left Upper Arm	1455	0.5	2.1	28.4	119	245	60	123
Right Upper Arm	1455	0.5	9.6	28.4	543	1145	272	573
Left Forearm	605	1.0	NA	28.4	2100	3426	2100	3426
Right Forearm	605	1.0	NA	28.4	11207	23683	11207	23683
Left Hand	410	1.0	NA	28.4	1423	2914	142	291
Right Hand	410	1.0	NA	28.4	7595	16001	760	1600
TOTAL DERMAL EXPOSURE					34103	70751	20101	41368

¹ Extrapolated from chest values and ratio of residues on front and back of legs.

² Not Applicable. No dosimeter used, exposure based on hand value.

Table B-5. Respiratory Exposure of Workers Applying Chlorpyrifos (Dursban) to Turf Using Power Hand Spray Equipment. Respiratory volume is assumed to be 1.7 m³ per hour.

Rep.	Spray Time	Flow Rate (ml/min)	Volume Sampled (L)	µg Found	Conc. (µg/cu m)	Exposure			
						(µg)	(µg/hr)	(µg/day)	(µg/kg/day)
1	30.0	197	7.9	0.020	2.53	2.15	4.30	21.52	0.31
2	30.0	197	14.2	0.040	2.82	2.39	4.79	23.94	0.34
3	27.7	205	14.1	0.016	1.13	0.89	1.93	9.65	0.14
4	28.7	205	16.0	0.037	2.31	1.88	3.93	19.66	0.28
5	29.9	206	20.6	0.024	1.17	0.99	1.98	9.90	0.14
6	26.9	NS ¹	NS	NS	NS	NS	NS	NS	NS
7	26.3	205	7.8	0.015	1.92	1.43	3.27	16.35	0.23
8	27.0	205	9.2	0.027	2.93	2.25	4.99	24.95	0.36
9	29.5	202	11.1	0.013	1.17	0.98	1.99	9.95	0.14
10	27.7	202	10.3	0.009	0.87	0.69	1.49	7.43	0.11
11	25.8	206	9.7	0.020	2.06	1.51	3.51	17.53	0.25
12	31.3	206	11.3	0.027	2.39	2.12	4.06	20.31	0.29
MEAN	28.4	203	12.0	0.02	1.94	1.57	3.29	16.47	0.24

¹ No Sample.

Table B-6. Summary of Exposures of Workers to Chlorpyrifos (Dursban) Applied to Turf Using Hand-Held Power Spray Equipment.

	Long sleeves, no gloves	Long sleeves, gloves	Short Sleeves no gloves	Short sleeves gloves	Respiratory
mg/hr	44.84	27.81	58.00	41.00	3.3×10^{-3}
mg/day	224.19	139.07	290.00	205.00	1.7×10^{-2}
mg/kg/hr	0.64	0.40	0.83	0.59	4.7×10^{-5}
mg/kg/day	3.20	1.99	4.1	2.93	2.4×10^{-4}